EON: CORBA-Based Middleware for Automation of Protocol-Directed Therapy

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Background. For several years, our laboratory has been studying aspects of automation of protocol-based therapy. In particular, we have examined the tasks of planning treatment in a manner consistent with protocol guidelines, and of determining from online medical-record data whether patients may be eligible for particular clinical protocols. Based on experiments in several clinical domains, we have developed a set of components that together help to automate various aspects of protocol-based care. We refer to this set of components collectively as EON.

System. Each of the modules in EON is a domain-independent "shell" that addresses a particular aspect of automating protocol-based care. These modules include: (1) reusable problem-solving methods that address tasks such as protocol therapy planning and protocol eligibility determination, (2) an electronic knowledge base that contains descriptions of clinical protocols and guidelines, and (3) Tzolkin, a database mediator that serves as the conduit for all queries of clinical data between the problem-solving components and a patient database. The Tzolkin system itself consists of two components: (1) the RÉSUMÉ system, which automates the task of generating relevant abstractions from time-oriented, point-based data (e.g., determining that *hematocrit values* in a certain range constitute intervals of *anemia)*, and (2) the Chronus system, which provides extensions to the standard relational data model to facilitate storage and retrieval of data that extend over temporal intervals.

All the knowledge of a given clinical application area on which the EON components might operate is stored separately in the electronic knowledge base. The knowledge base defines the broad classes of medical interventions, laboratory tests, and drugs that may be relevant in a particular area of medicine. For example, in the domain of AIDS therapy, we constructed a system known as T-HELPER. We defined general classes of AIDS-related concepts in an *ontology* of HIV therapy. We also created knowledge bases that specified *instances* of the classes in the AIDS ontology (e.g., that AZT is an instance of a drug), and that indicated how the instances of the concepts constituted particular protocols (e.g., how AZT might be given for antiretroviral therapy).

Concomitant with development of EON, our laboratory has created Protégé, a methodology and a suite of tools that facilitate the construction of the kinds of large knowledge bases required by EON. We have used Protégé to develop the knowledge bases used by the T-HELPER system and other EON-based implemenations. Protégé allows us to generate automatically knowledge-acquisition tools that permit users to define clinical protocols in domain-specific terms.

Because the modules in the EON architecture are domain-independent shells, we can substitute new knowledge bases that define medical care in a variety of medical specialties to facilitate protocol-based care in these new domains. The domain-independent components in EON then can operate on the new knowledge bases without the need for reprogramming. In all cases, we assume that the EON components and their associated knowledge bases will be embedded within some larger clinical information system, and that interoperation among the components is achieved via the industry-standard Common Object Request Broker Architecture (CORBA).

Evaluation. We have applied the EON components to automate protocol-based care in the domains of AIDS and breast cancer. We reused the core EON components without reprogramming—mapping those components to the detailed protocol knowledge bases constructed that we built using the Protégé approach.

Conclusion. The middleware components of the EON architecture are reusable software modules that operate on explicit knowledge representations to generate advice regarding guideline-directed therapy. Reuse of the EON components within new information systems can lead to rapid development of CORBA-compliant decision aids for protocol-based care.

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